GEOPHYSICAL INSTITUTE

OF THE

UNIVERSITY OF ALASKA

ROCKET INVESTIGATIONS OF THE AURORAL ELECTROJET

NGR 02-001-025

Final Report

October 1973

Principal Investigator:

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I. NATURE OF THE PROGRAM

This contract (NGR 02-001-025) was awarded for the preparation and flight of five experimental packages. In addition comprehensive ground observations were to be made in conjunction with the rocket experiments to determine the appropriate times for the flights and to monitor variations in the magnetic field and the aurora during the course of each flight.

The series of five Nike-Tomahawks (UE 18.13 - 18.17) was originally developed to measure perturbations in the magnitude of the geomagnetic field due to auroral electrojets by means of rubidium vapor magnetometers. This followed after successful identification programs involving the measurement of the equatorial electrojet and the Sq mid-latitude current system. Particle counters and photometers were added to the instrumentation. Partly to minimize magnetic interference from the vehicle itself, the magnetometer was carried in a forward section of the payload which was separated from the rear section by springs after the vehicle had left the dense atmosphere. Advantage was taken of the resulting mother-daughter configuration to make particle measurements at two separated points along the trajectory.

The five rockets were launched at locations and dates as shown below:

Rocket	Date	Location
18.13	March 1968	Ft. Churchill
18.15	17 March 1969	Poker Flat
18.16	10 February 1970	Ft. Churchill
18.14	15 March 1971	Poker Flat
18.17	20 March 1971	Poker Flat

All flights had some measure of success and several were particularly successful in acquiring particle data on both mother and daughter components of the payloads.

In addition to conducting these rocket flights we also performed supporting observations in October 1968 for barium release rockets flown in Norway.

II. SCIENTIFIC RESULTS

Prior to the completion of this contract the only publication was a Ph.D. thesis by A. D. Johnstone, completed May 1970. However, papers published later that utilized work completed or data obtained within the time frame of the contract are as follows:

Johnstone, A. D. Measurements of low energy protons in a pulsating aurora, Ph.D. Thesis, Univ. of Alaska, Fairbanks, May 1970.

Johnstone, A. D., Correlation between electron and proton fluxes in post-breakup aurora, J. Geophys. Res., 76, 5259, 1971.

Johnstone, A. D., The spreading of a proton beam by the atmosphere, Planet. Space Sci., 20, 292, 1972.

Johnstone, A. D., The geomagnetic factor of a cylindrical plate electrostatic analyser, Rev. Sci. Inst., 42, 1030, 1972.

Boyd, J. S., T. N. Davis, N. B. Brown, T. J. Hallinan and D. D. Wallis, Observations of fast auroral waves, Planet. Space Sci., 20, 437, 1972.

Davis, T. N. and D. D. Wallis, Observations of ionospheric motions using barium ion clouds, Space Research XII, 935, 1972.

Boyd, J. S., Rocket measurements of precipitating electrons in a system of multiple auroral arcs, Ph.D. Thesis, Univ. of Alaska, Fairbanks, July 1973.

Johnstone, A. D. and T. N. Davis, Low altitude acceleration of auroral electrons during breakup observed by a mother-daughter rocket, accepted by J. Geophys. Res.

Johnstone, A. D., J. S. Boyd and T. N. Davis, Study of a small magnetospheric substorm, accepted by J. Geophys. Res.

The abstract of Johnstone's thesis is reproduced below and more comprehensive discussion of the general scientific results of this project is given in the Final Report on Contract NGR 02-001-080, dated November 1973.

"A Nike-Tomahawk rocket carrying particle detectors was launched into a display of pulsating aurora in the recovery phase of a large auroral substorm. The proton energy spectrum between 3 kev and 30 kev found that the differential energy spectrum had the form AE^{-r} with r varying from 2.1 to 2.9. Above the atmosphere the pitch angle distribution was flat, i.e., the greatest intensities were at pitch angles of 90^{o}. Below an altitude of 200 km the protons were scattered considerably in collisions with atmospheric molecules. Below 160 kms the pitch angle distribution was essentially isotropic. There were time variations in the proton count-rate too fast to be attributed to spatial variations in the proton flux when spreading of the beam by charge-exchange cycling is taken into account. The variations correlate with changes in the electron flux such that the proton spectrum softens and the electron spectrum hardens during the event. The precipitated flux of both electrons and protons

increases. It is suggested that the effect is caused by the operation of a mechanism described by Swift which energizes electrons at the expense of ring current proton energy. This may be the reason that electron precipitated fluxes are greater than proton fluxes although the trapped proton energy is 2 to 3 times greater than the trapped electron energy. The electron energy flux was 10 times the proton energy flux with a total of more than 10 ergs cm^{-2} sec^{-1} being precipitated continuously. It is estimated that, during the substorm, nearly 10^{21} ergs were precipitated into the northern and southern auroral zones. Comparing the data collected with known ring current morphology it is suggested that proton energy is being injected into the ring current in the tubes of force which connect to the substorm."